2009

The Management of Verbal Communications in Complex Aeronautical Systems

Fanny Loyau

Marie Rivenez

Sophie Quiblier

THE MANAGEMENT OF VERBAL COMMUNICATIONS IN COMPLEX AERONAUTICAL SYSTEMS

Fanny Loyau
Marie Rivenez
Sophie Quiblier
French military institute of biomedical research - IRBA
Brétigny Sur Orge - France

This study addresses the question of human factors in verbal communications in AWACS (Airborne Warning and Control System). It aims to improve selection, training and learning by developing a tool focused on attentional division and multiple communications management. Radio communications management seems to be highly dependent on crew expertise. Indeed, many instructors say that several years of experience on AWACS are required in order to develop communications management skills and to improve their intelligibility. On the basis of our preliminary observations, we propose three hypotheses which would account for this expertise effect, focused on automatisms, volumes management of radio networks and attentional division. In the first hypothesis we assume that experts would benefit from more attentional resources for communications management compared to beginners because experts automate technical tasks. A laboratory experiment was designed for testing this hypothesis. Our goal is to improve technical training for operators in communications management.

Aeronautical military systems are increasingly complex. They involve many participants, fighter pilots, transport pilots, and air traffic controllers. They have a common tool, verbal communication, which is crucial to mission success and to maintaining a high level of safety. But verbal communication is still a human tool. It requires good transmission and good understanding. Thus, there is an element of uncertainty, which can lead to misunderstandings, impairment of the mission, incidents or accidents.

A Pre-Study: Context and Hypothesis

A preliminary study revealed difficulties associated with radio communications in AWACS (Airborne Warning and Control System), integrated into the aircraft E-3F Boeing 707 (Picture 1). These planes belong to the French Air Force and are part of the EDCA (« Escadron de Détection et Contrôle Aéroporté ») on the Avord base. Their mission is to monitor and control air (and sometimes sea) operations through detection and data transmission. The crew of an AWACS consists of 18 persons, 4 members for the flight crew and 14 for the mission crew. This mission crew performs several functions: control, surveillance and technology.

Picture 1. An E-3F Boeing 707 AWACS

All crew members express the same difficulty: understanding verbal communications, because of the large number of personnel on board associated with external partners. This generates many verbal interactions, much audio information in addition to non-verbal sounds such as alarms, and noise from the environment: engine noise and aerodynamic noise. This can lead to misunderstanding, loss of information, particularly for novices. According to instructors, expertise plays an important role in the ability to manage voice communications through the development of skills, including technical tasks routinization.

Routinization of Technical Tasks

Characteristics of the AWACS Sound Environment

The sound environment in AWACS is composed of simultaneous sounds and messages. This leads to the phenomena of masking, energetic and informational, which causes degradation of speech intelligibility. Energetic masking results from spectral and temporal superimposition of simultaneous speech signals (Moore & Glasberg, 1987; Brungart, 2005). When this occurs it is impossible to understand one of the signals. This type of masking cannot be reduced by technological means. However, our goal is not to act on the interface, but on the operator and practices he uses to remove ambiguities. We do not therefore look at this type of masking. Informational masking occurs when relevant and interfering messages are audible, but auditors are not able to understand the relevant message while ignoring interfering messages (Brungart & Simpson, 2002).

Operators' Adaptation

In the context of AWACS, there are several ways of minimizing this informational masking, including routinization: Operators reduce the attentional load required for technical tasks by automating these tasks in order to provide more resources for communications management. The principle of routinization is a saving of cognitive resources through the development of automatic skills operation. More resources are then available to perform another task in parallel. This is a standard component of expertise (Amalberti, 1996). Indeed, AWACS instructors say that with experience they have more attentional resources to manage verbal tasks because technical tasks, with routinization, do not require much attention. In contrast, novices are more likely to favor one of these tasks at the expense of another.

This can be explained by the fact that the existing training tool does not assess the level of routinization achieved by staff and manages very little verbal communication.

A Double Task Experiment

We would like to develop a tool that allows novices both to carry out routinization of technical tasks, and to further improve their management of verbal communications. This tool should be an indicator of routinization level and contribute to this practice, with the hypothesis that a double learning task is more efficient than a single task. A laboratory experiment was set up, consisting of a routinization task and an intelligibility task, which could simulate technical tasks and operator communications in real situation.

The Technical Task

The technical task should be a slow routinization task, i.e. a task that becomes increasingly automatic as learning proceeds. As part of AWACS, it corresponds to the routinization of tasks by experts but not by novices at the end of their practical training. It is the only type of routinization (as opposed to rapid routinization and non routinization) for which training will enable novices to be operational on early missions. The technical task can be simulated by using a protocol which has been tested several times and has a good indicator of the degree of routinization (Amato, 2005; Bourgy, 2007).

This task was a simulation of piloting at Charles de Gaulle Airport. The operator had to learn the procedure without making mistakes: he had a plan, which we asked him to ignore as soon as possible. The route consisted of several views of the airport. In each case, there were several possible directions, only one was the right direction. By simply clicking in the desired direction he moved forward. Each test resulted in a score measured in route time and in error percentage. This task was considered as a routinization task when the error percentage was virtually zero and when the route completion time was fast and stable.

The Verbal Task

The verbal task in this experiment should interfere with a non-routinization task and interfere little with a routinization task. It was built on the premise that the intelligibility of a speech message can be measured using the Coordinate Response Measure (CRM), developed by Moore (1981) and tested by Brungart (2001). This tool enables evaluation the degradation of intelligibility due to informational masking.

The CRM is a verbal instruction asking the participants to choose a number of a certain color on a screen. The message is in the form "Ready [call sign], go to [number][color] now"(e.g. "Charlie Ready, go to green four now »). It is presented at the same time as one or several other messages of the same form but with different call sign, number and color. Listeners recognize the relevant message through the target call sign (in our example, "Charlie"). The ability to follow the relevant message is determined by measuring the percentage of attempts in which subjects select the number specified in the relevant message.

In our experiment, this methodology was used in part: verbal stimuli were 16 phrases in English, from the combination of a call sign ("Charlie"), 4 colors ("red", "blue", "green" "white") and 4 numbers ("one", "two", "three", "four") pronounced by a woman. Each sentence takes approximately 1500 milliseconds. Participants give their answers in a box with 4 colored buttons (red, blue, green, white) and 4 white buttons showing numbers (1, 2, 3, 4). Each test is used to obtain a score of intelligibility, as measured by percentage of correct answers (correct identification of color and number).

Procedure

The experiment is conducted in two phases: (1) - a learning phase and (2) - a test phase.
(1) - The first phase (single task phase) is to learn the route and, separately, to learn the verbal task. A group of participants should make 54 route tests in order to achieve routinization of the task (routinization group). Another group of participants should make only 9 route tests in order to just familiarize themselves with the task (familiar group). Both groups were subjected to 15 sets of 100 sentences (1500 MRC phrases) to familiarize themselves with the use of the answer box.
(2) - The second phase (double task phase) is the completion of the route simultaneously with the verbal task. All participants perform 63 tests in the double task.

Participants

Twenty-four naive participants were involved in the experiment, 14 women and 10 men, for a mean age of 32 years. Half of them were placed in the routinization group and the other half in the familiar group. These subjects had no hearing trouble, and their laterality was respected: they used the mouse with their dominant hand.

This protocol is used to determine the best method of learning (associate the verbal task from becoming familiar with the technical task or after routinization of the technical task). The best way of learning is obtained by comparing the number of tests necessary to obtain equivalent performances between routinization and familiar groups.

Materials

Participants were in a soundproof room, facing 4 screens on a desk. These screens were connected to a computer running Windows. To respond, the subjects had a mouse and an answer box with standard key spacing. The experimenter had a computer with Matlab, to load the sounds for the intelligibility task, and a TDT, a processor used to start each sound and to collect responses from the answer box.

First results

Before discussing the results themselves, it was necessary to examine certain pre-conditions.

First, group homogeneity was verified using the single task. There was an equivalency of route time (for the first nine) (Figure 1). It's in line with what we expected in that we assumed that the groups had similar performance to the technical task because they are based on the same level of experience, which is zero.

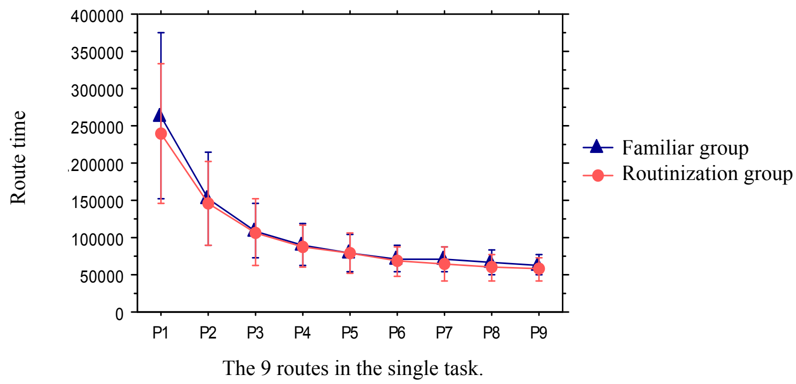

Figure 1. Route times for the nine first routes.

For performance of the MRC task (Figure 2), there is a difference between the groups: the familiar group has the lowest performance at the MRC in single task. This performance difference may simply be due to chance. It may also be that the technical task, carried out before the single task, is longer for the routinization group, which could lead to a difference of concentration or motivation.

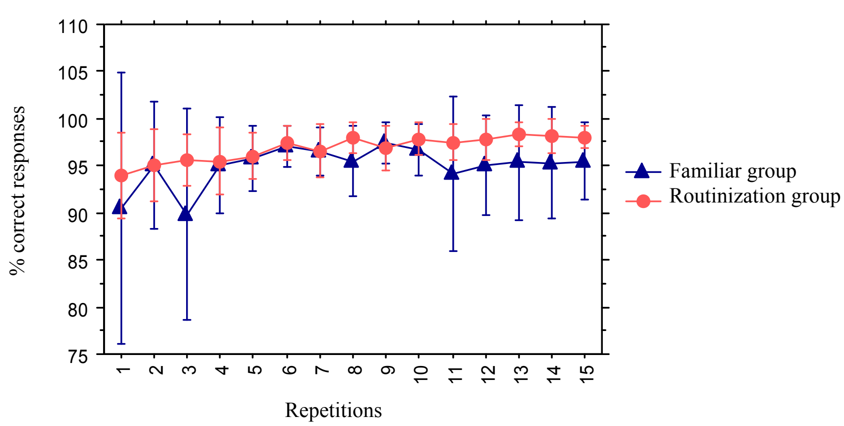

Figure 2. Performance of the MRC task.

Second, in the double task, performance of the MRC task was lower for the familiar group (Figure 3). In order to compare the participants in terms of attentional resources allocation to the verbal task, it is necessary they have the same performance. For this, only the rates of correct responses above 95% were retained. There is a very significant effect of repetition for the two groups: more they make routes, more they are progressing. There is also a significant effect of group: the routinization group is significantly better than the familiar group.

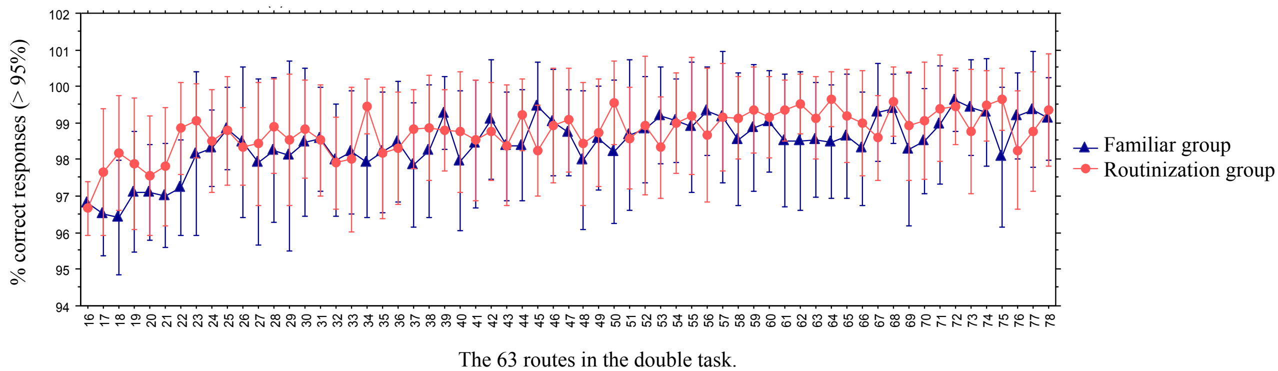

Figure 3. Performance of the MRC task in the double task

Conclusions

Prerequisites have been verified; the homogeneity of the groups for the technical task was confirmed. In contrast, performance for intelligibility on the double task could not be verified. Indeed, the familiar group focused less on the intelligibility task and therefore spent more time on the path times.

The next step of the study will consist of the statistical analysis of results.

On the one hand, the cost of the MRC task will be determined. Our hypothesis is that, during the transition from single task to double task, there would be a cost of the MRC task for the familiar group, and it would be low or even zero for the routinization group, ie the familiar group would take more time than the route time for the single task.

On the other hand, the contribution of learning on the single or the double task will be established. Our hypothesis is that learning on the double task is more effective than on the single task. The question is to determine how many repetitions it took the familiar group to achieve the performance of the routinization group, if they achieve this performance.

Perspectives

The tool used in our experiment could be an indicator of the level of routinization, if it interferes more with a non routinization task than a routinization task. This tool could be improved in order not to interfere at all with a routinization task.

In the longer term, the applied aim of the project is the creation of an operational tool for the training of the AWACS mission crew, which implies respect for the ecology of the technical task. Two possibilities are envisaged: either the addition of the verbal task to the existing simulator, or the creation of a simulator dedicated to training on the double task. A feasibility study will be necessary.

We shall then consider two others aspects of expertise in relation to the management of verbal communication in AWACS: strategies for the management of sound levels, and division and focalization abilities of attention.

Acknowledgments

The authors would like to thank Véronique Chastres for her helpful for the statistical analysis.

References

Amalberti, R (1996). La conduite des systèmes à risques. Paris: PUF, Le Travail Humain.

Amato, J.-N., Ardouin, J.-C. & Amalberti, R. (2005). Le contrôle cognitif des activités routinières en situation dynamique : cadre théorique et montage expérimental. Rapport de recherche. Institut de Médecine Aérospatiale du Service de Santé des Armées. Paris, France.

Bourgy, M. (2007): Le contrôle cognitif des activités routinières en situation dynamique : étude expérimentale des régulations implicites liées à l'humeur du sujet. Rapport de recherche. Institut de Médecine Aérospatiale du Service de Santé des Armées. Paris, France.

Brungart, D. S. (2001). Evaluation of speech intelligibility with the coordinate response measure. *Journal of the Acoustics Society of America*, 109, pp. 2276-2279.

Brungart, D. S. (2005). Informational and energetic masking effects in multitalker speech perception. In P. Divenyi (Ed), Speech separation by human and machine, Kluwer Academic Press: USA, pp. 261-267.

Brungart, D. S. & Simpson, B. D. (2002). Within-ear and across-ear interference in a cocktail-party listening task. *Journal of the Acoustics Society of America*, 112, pp. 2985-2995.

Moore, T. J. (1981). Voice communication jamming research. *In AGARD Conference proceedings 331*: Aural Communication in Aviation, Neuilly sur Seine, France.

Moore, B. C. J. & Glasberg, B. R. (1987). Factors affecting thresholds for sinusoidal signals in narrow-band maskers with fluctuating envelopes. *Journal of the Acoustics Society of America*, 82, pp. 69-79.